13. (New) A method for achieving flow through a flow control valve in a well having a tubing concentrically spaced within a casing by an annulus, comprising the steps of:

placing a gas lift valve within the well at, a predetermined location, said gas lift valve having an inlet end in communication with said annulus, and an outlet end in communication with an interior of said tubing;

flowing compressed gas of density less than a density of reservoir fluids into the annulus;

flowing the compressed gas from the annulus into a convergent nozzle portion of the gas lift valve;

gradually accelerating gas flow through said nozzle portion;

gradually slowing down said gas flow in a divergent outlet portion of the gas lift valve, thereby reducing the gas pressure loss and rendering the gas flow isoentropic; and

mixing gas ejected from the outlet portion of the gas lift valve with reservoir fluids in the tubing.

14. (New) A method as in claim 13, further comprising flowing gas ejected from the outlet portion through a check valve before said mixing step. --

REMARKS

A CPA request is concurrently filed. Reconsideration and allowance in view of the foregoing amendment and the following remarks are respectfully requested.

Claims 4-14 are now pending.

The Examiner noted applicant's request under 37 CFR 1.607 and advised that the request has been denied at this time because the allowability of claim 4 has been withdrawn. It is respectfully requested that upon re-allowance of claims in this case, applicant's request be reconsidered and that an interference be declared as requested. Claims 4-14 correspond to the counts previously proposed.

The specification has been revised above to mention the check valve shown in Figure 1. A proposed drawing correction is attached in which the check valve is labeled. No new matter has been added.

Claim 4 was rejected under 34 USC 112, second paragraph, as being indefinite. The preamble of claim 4 has been revised above to obviate the grounds for this rejection. Reconsideration and withdrawal of the rejection are requested.

Claim 4 was rejected under 35 USC 103 as being unpatentable over Jaikaran. (US 5,374,163). Applicant respectfully traverses this rejection.

At the outset, it is respectfully submitted that Jaikaran is not statutory prior art with respect to this application. As the Examiner will note, a certified copy of applicant's priority document was submitted with the Rule 607 request. Thus, applicant is entitled to the priority date of January 27, 1993. Jaikaran was filed in the U.S. Patent Office on May 12, 1993, <u>after</u> applicant's perfected priority date. Therefore, Jaikaran is <u>not</u> prior art with respect to this case.

It is further respectfully submitted that <u>on the merits</u>, the invention of applicant's claims is not anticipated by nor obvious from the disclosure of Jaikaran.

The Jaikaran patent deals with a artificial lift system know as jet pumping. Previously, the Examiner cited the Weeks patent, US 4,726,420, which is also a jet pumping system and applicant previously presented arguments distinguishing the invention claimed from such a jet pumping system.

The basic idea of a jet pumping (of which the Jaikaran patent is a variant) is the use of a high pressure fluid flow (driving fluid; usually water), impelling it through a nozzle where the potential energy (pressure) is transformed into kinetic energy. This pressure drop occurs in the throat (the central part) of a venturi and the fluid from the oil well is "sucked" up through the venturi. There is a mixture of the two flowing fluids (the driving fluid and the produced fluid) in the throat and after it there is a diffuser that allows a partial pressure recovery that is sufficient to carry the fluids up to surface.

The physical principle of jet pumping is completely different from gas lift, to which the invention relates. In gas lift, high pressure gas enters into the pipe (production casing) at a certain point of injection, producing a reduction of the fluid density. The gas lift method is similar to the natural surge production process, in which the energy for the well production is supplied by the reservoir itself. Thus, gas lift is used as a supplement, to provide the gas flow needed for production that is not available from the reservoir, in order to produce oil from a well at a desirable flow rate.

This is illustrated by Fig. 3.41-B of page 138 of Brown, K. E., "The Technology of Artificial Lift Methods", v. 2a, Petroleum Publishing Co., Tulsa, 1980. (attached here to as Annex A). In this situation, a well is producing at a certain flow rate due to the difference between the reservoir static pressure (PR) and the flowing bottom hole pressure. When the depth decreases, the flowing pressure also decreases at a rate Gfb that is a function of the gas amount present in the reservoir. From the gas injection point (depth L), the rate of pressure reduction becomes smaller (Gfa) due to the gas supplied by the well annulus mixing with the fluid flowing from the reservoir. This injection occurs with a relatively small annulus-tubing pressure differential (100 psi in the figure) in relation to the fluid flow pressure at the injection point. With such gas injection the produced fluid flow is able to achieve the surface at the pressure Pt required by the oil processing facilities.

The gas admission for gas lift can be achieved by drilling a single hole in the tubing or by another more sophisticated device, such as a gas lift valve. In accordance with applicant's invention, the round orifice in a conventional gas lift valve is replaced with a venturi, reducing the localized head loss and allowing the injection of large gas flow rates even with very small pressure differentials between the annulus and the tubing. It should be noted, therefore, that the gas pressure in the annulus at the injection point does not need to be much bigger than the flowing pressure in the tube, being only enough to perform the required gas flow rate injection. The lift valve with venturi disclosed and claimed by applicant reduces this difference to a minimum value.

For jet pumping, the energy for recovering the production fluid is supplied by a driving fluid (usually water or oil) at a very high pressures. The idea is based on the energy conservation law expressed by Bernoulli's equation:

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

As $h_1=h_2$, if $v_2 > v_1$, than $p_2 < p_1$. Thus, having a fluid with high pressure, it can be accelerated in an ejector nozzle, thereby reducing its pressure. In broad terms, "pressure energy" is converted into "kinetic energy". If the pressure at the nozzle outlet is sufficiently small there will be a fluid flow from the reservoir up to the nozzle region. Downstream of the ejector is installed a diffuser that has the function of decelerating the flow. Thus, in accordance with Bernoulli's equation, the "kinetic energy" is converted back into "pressure energy" again. The pressure at the diffuser outlet is then adapted to be sufficient to promote the fluid flow (reservoir fluid plus driving fluid) up to the surface. Actually, p_2 is always smaller than p_1 because besides the mixture with the two fluids there is a considerable and irreversible loss in the process (friction).

Figure 1, attached hereto as Annex B, shows a schematic pressure profile for a well producing by jet pumping based on the profile for gas lift shown in Annex A. At the point where the ejector is placed (herein considered at the same installation depth of a gas lift valve), just after the diffuser, there is a pressure recovery which has to be sufficient to allow the production of the combined flow (reservoir fluid plus driving fluid) and to fulfill the pressure condition at the surface (P_t). The rate of pressure variation related to the depth above the ejector (G_{fc}) is larger than the same below de ejector (G_{fb}), but for the sake of simplification in the illustration, $G_{fc}=G_{fb}$.

Once there is irreversible energy losses, the pressure differential between the driving fluid and the flowing fluid is larger than that existent between the diffuser inlet and outlet. There is, therefore, the necessity of Δp_1 in order to compensate such "head loss". With the injection pressure required at the ejector and the rate of pressure variation (Gfd, considered in the illustration to equal to Gfc, for simplification) one obtains the driving fluid required at the surface. A copy of a part of a technical paper

from Grupping, et al., "Fundamentals of Oilwell Jet Pumping", SPE Production Engineering, February 1988 (pages 9-11) is attached hereto as Annex C, where one can observe in Fig. 2 a more detailed scheme for a typical pressure pattern for a jet pump that confirms the scheme shown on Fig. 1, Annex B. The pressure differential p_n-p_d corresponds to the irreversible losses Δp_1 on Fig. 1, Annex B. The Fig. 1 from Grupping et al. shows a identical scheme as shown in the Jaikaran patent, confirming that such patent is, in fact, slightly different from the state of art.

It is thus clear what the differences are between gas lift and jet pumping. In the first, one supplements gas that should exist in the reservoir if the well was producing from natural surge at the specified flow rate. In the second, one supplements energy directly to the fluid flow, such as using a positive displacement pump. An additional significant difference is that when using gas lift, the well fluid never flows through the gas lift valve.

In the rejection, the Examiner has asserted that Jaikaran controls the flow of an oil or other production fluid, citing column 1, lines 5-9. Actually, Jaikaran is not characterized as controlling the flow of an oil or other production fluid. Rather, at column 1, lines 5-9, Jaikaran states "The present invention relates generally to the field of down role pumping apparatus and, more particularly, to a venturi-type, positive displacement pump for withdrawing oil or other production fluid from producing structures".

From the above paragraph "one of ordinary skill in the art" can read that the Jairkaran is related to a fluid impelling equipment, a pump, not a fluid control device. The term "venturi-type" is only one from several possible designations of the jet pump, such as shown in Fleshman, et al. "Artificial Lift for High-Volume Production", Oilfield Review (Schlumberger Publishing), Spring 1999, page 50 (attached hereto as Annex D).

The Examiner's apparent misunderstanding is further evident from the Examiner's statement that it would be "an obvious design expedient... to use gas as the production fluid". Applicant respectfully but strongly disagrees. For the reasons noted

above, it would not be an obvious design expedient to interchange parts of a jet pumping system and a gas lift system. As noted above, the systems are materially different and the Examiner has cited no evidence suggesting that their parts are considered interchangeable and/or mutually obvious expedients in one another.

Furthermore, the Examiner has apparently confused driving fluid with production fluid. It is not possible to choose the production fluid; it is chosen by "Mother Nature". Even if the Examiner intended to suggest the use of gas as a driving fluid in Jaikaran, that would not change the fact that jet pumping is fundamentally different from a gas lift valve in disposition and in the way in which it achieves movement of the production fluid. It isn't obvious from the use of a venturi structure in a jet pump that such a structure would be of any use or advantage in gas lift. In jet pump the venturi is used for a pressure recovery in the diffuser, promoting what one can classify broadly as a "pump effect", supplying pressure energy to the fluids to be pumped. In gas lift, the venturi provided in accordance with the invention is a gas injection flow rate control device. Due to its peculiar characteristics, applicant has discovered that in a gas lift system, a venturi easily meets the necessary constant gas injection flow rate when compared with the conventional flow rate control device (orifice). This would not be known or appreciated from a venturi structure in a jet pumping system.

The Examiner has said that "by laws of fluid dynamics result in the gas flow being gradually slowed down in the restricted Venturi passage of the nozzle, reducing the gas pressure loss and rendering the flow isoentopic". Actually, what happens is that the fluid is accelerated at the nozzle and consequently its pressure is reduced (see Bernoulli Equation above). The flow from a jet pump is far from an isoentropic one. As can be seen from Fig. 1, Annex B, or from Fig. 2, Annex C, there is a significant head loss Δp_1, as per Noronha et al, Annex E. Even if the flow was considered to be isoentropic, it isn't obvious that the gas flowing through the a gas lift valve should be isoentropic. The conventional gas lift valve was considered as a simple gas injection flow rate control device and performed well its service. However, the gas flow through the conventional round orifice plates was far from isoentropic,. The necessity for isoentropic flow has arisen due to the new scenario for oil production using gas lift,

mainly in offshore areas. In accordance with the description provided in applicant's patent application, more precise gas flow rate mathematical modeling was required and a lower pressure differential between the annulus and the tubing to allow the gas injection at deeper points was needed in order to obtain a substantial increase in the production flow rate.

Applicant is not suggesting that they have invented the venturi per se, and neither did Jaikaran. Applicant's invention is the improvement to the continuous gas lift method that occurs when the gas flow through the gas lift valve is as close as possible to an isoentropic flow. This improvement is achieved by providing the venturi type orifice claimed.

Thus, there is no analogy whatsoever between the jet pumping apparatus of Jaikaran, or any other jet pumping system, and the present invention. The structures are disposed differently in the well and achieve fluid flow in different ways. The jet pump venturi structure is disposed in the production tubing to suck the production fluid with the driving fluid therethrough, whereas the gas lift valve is disposed to connect the annulus to the production tubing, to flow gas into the production fluid, but is not disposed for production fluid flow therethrough. It is therefore respectfully submitted that the invention is not anticipated by nor obvious from Jaikaran, Weeks or any other similar such jet pumping system.

Claim 4 was also rejected under 35 USC 103 as being unpatentable over Corteville et al. Corteville has patented a device to allow equipment installation and removal from/to inside pipes, mainly those of oil wells. Corteville et al describes, as a possible application, a jet pump designed in such a manner that it can be installed and removed when necessary. Nevertheless, Corteville relates to a jet pump and thus, for the reasons advanced above with respect to Jaikaran, does not teach or suggest a gas lift valve as recited in applicant's claims. It would not be obvious to one skilled in the art, without the benefit of applicant's disclosure, to use a jet pump structure, as mentioned in Corteville, as a gas lift valve.

For the reasons advanced above, reconsideration and withdrawal of the rejection over Corteville is requested.

Claim 4 was also rejected under 35 USC 103 as being unpatentable over Short. Applicant respectfully traverses this rejection.

Short has disclosed a jet pumping system that uses gas the drive fluid. The gas passes through an ejector in order to convert pressure into velocity and is flowed by the pressure recovered at the diffuser. There is a benefit in reducing the pressure at the pump outlet due to the low density gas that mixes with the reservoir fluid (contrary to the traditional driving fluids that have high density), but the low density of the gas implies a poor conversion of the kinetic energy into pressure energy in the jet pump (see in the Bernoulli equation the presence of specific density in the kinetic term). Consequently, it is necessary to have a very large gas flow rate and pressure to compensate for the pressure loss in the ejector nozzle. Applicants do not have an ejector in the disclosed invention because it is not needed. Aside from the fact that Short uses gas as a driving fluid, Short is no more relevant to the invention claimed than the other jet pumps described above. Indeed, Short does not teach or suggest that his jet pump structure would be of any use or advantage as a gas lift valve structure. His structure is disposed differently than a gas lift valve in the well and is adapted to achieve fluid flow in a different way than a gas lift valve. Short's structure is disposed in the production tubing to suck the production fluid with the driving fluid therethrough, whereas a gas lift valve is disposed to connect the annulus to the production tubing, to flow gas into the production fluid, but is not disposed for production fluid flow therethrough.

For all the reasons advanced above, reconsideration and withdrawal of the rejection over Short is requested.

Attached is a Form PTO-1449 listing the enclosed documents.

This Information Disclosure Statement is intended to be in full compliance with the rules, but should the Examiner find any part of its required content to have been

omitted, prompt notice to that effect is earnestly solicited, along with additional time under Rule 97(f), to enable Applicant to comply fully.

Consideration of the foregoing and enclosures plus the return of a copy of the herewith Form PTO-1449 with the Examiner's initials in the left column per MPEP 609 along with an early action on the merits of this application are earnestly solicited.

All objections and rejections having been addressed, it is respectfully submitted that the present application is in condition for allowance and an early Notice to that effect is earnestly solicited.

A Power of Attorney appointing the undersigned is attached. Please direct all future correspondence to the undersigned at the address below.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

Please replace the paragraph beginning at page 2, line 15, with the following rewritten paragraph:

--Figure 1 is a sketch of a gate valve type of gas-lift valve currently in use. In the Figure there is a point marked A where gas enters the valve, passes through the valve seat B (that is, the gate), passes check valve C and leaves out of nose D [C] for the inside of the pipe, Figure 1 also shows a detailed view in section of the seat, shown as a sketch in Figure 2, in which the cylindrical body of valve 1 can be seen, the housing 2 for the seat, and the seat 3, the gate 4 and o ring 5.--

IN THE CLAIMS

Please substitute the following amended claims for corresponding claims previously presented. A copy of the amended claims showing current revisions is attached.

4. (Amended) [An apparatus for controlling gas lift in] In an oil well having a casing with tubing concentrically disposed therein, an apparatus for controlling gas lift, said apparatus comprising a gas lift valve mounted on said tubing and having an inlet end in communication with a space between said tubing and said casing and an outlet in communication with an interior of said tubing, said gas lift valve consisting of a housing and a nozzle mounted in said housing, said nozzle having a continuously open passage through which gas is allowed to flow, wherein said passage consists of a curved inlet portion through which gas flow is speeded up, a smooth straight, intermediate portion providing a main restriction to gas flow and a smooth, outwardly tapered, conical shaped outlet portion through which said gas flow is gradually slowed down, reducing the gas pressure loss and rendering gas flow isoentropic.

Kindly add the following new claims:

--5. (New) In oil well having a casing and a tubing with an annulus defined therebetween, an apparatus for controlling the flow of gas from said annulus into said tubing, said apparatus comprising:

a gas lift valve mounted on said tubing and having an inlet end in communication with said annulus for admitting gas from said annulus into said gas lift valve, and an outlet end in communication with an interior of said tubing, for discharging gas into said tubing;

said gas lift valve including a housing and a nozzle mounted in said housing, said nozzle being provided with a continuously open passage through which gas is allowed to flow, said passage comprising:

a convergent inlet portion through which gas flow is gradually accelerated, and

a divergent outlet portion through which said gas flow s gradually slowed down, thereby reducing the gas pressure loss and rendering the gas flow isoentropic.

6. (New) An oil well as in claim 5, further comprising:

a smooth straight intermediate portion located between said curved inlet portion and said tapered outlet portion, said intermediate portion providing a main restriction to said flow.

7. (New) In a gas lift system for injecting pressurized gas into a well having a production string, a gas flow control valve comprising:

a housing including at least one inlet port and at least one outlet port;

an orifice comprising a nozzle portion and a diffuser portion;

said nozzle portion including a nozzle first end, a nozzle second end, and a nozzle flow path between said nozzle first end and said nozzle second end; said nozzle flow path converging from said nozzle first end to said nozzle second end, such that the gas experiences a decrease in pressure;

said diffuser portion including a first end and a second end, and a diffuser flow path therebetween,

said diffuser flow path diverging from said diffuser first end to said diffuser second end, such that the gas experiences a rise in pressure, said diffuser first end being disposed adjacent said nozzle second end, such that a throat is defined therebetween, said diffuser flow path being aligned with said nozzle flow path to provide a continuous flow path;

whereby said pressurized gas flows into said at least one inlet port of said gas flow control valve through said continuous flow path, and out through said at least one outlet port into said production string.

8. (New) A gas lift system as in claim 7, further comprising a check valve downstream from said diffuser portion responsive to said flow of pressurized gas.

9. (New) The device of claim 7 wherein said diffuser has a conical contour.

10. (New) A device for controlling a flow of gas from an external source into well tubing to enhance lift of fluid in the tubing comprising:

a gas lift valve insertable in the tubing, said valve having a housing with an upper portion having at least one inlet port for admitting the gas from the external source into the valve, a lower portion having at least one outlet port for discharging the gas from the valve into the tubing and a mid-portion extending therebetween on a longitudinal axis, and an orifice mounted within said housing mid-portion, said orifice having a throat transverse to and symmetrical about said longitudinal axis, a nozzle extending upwardly from said throat and diverging symmetrically outwardly from said axis and a diffuser extending downwardly from said throat and diverging symmetrically outwardly from said axis, said orifice defining a path of flow of gas from said upper portion to said lower portion of said housing;

said nozzle including a nozzle first end, a nozzle second end, and a nozzle flow path between said nozzle first end and said nozzle second end, said nozzle flow path converging from said nozzle first end to said nozzle second end, such that the gas experiences a decrease in pressure;

said diffuser including a first end and a second end, and a diffuser flow path therebetween, said diffuser flow path diverging from said diffuser first end to said diffuser second end, such that the gas experiences a rise in pressure, said diffuser first end being disposed adjacent said nozzle second end, such that flow is achieved in said throat, said diffuser flow path being aligned with said nozzle flow path to provide a continuous flow path;

whereby said gas flows into said at least one inlet port of said housing through said continuous flow path, and out through said at least one outlet port into said tubing.

11. (New) A device as in claim 10, further comprising a check valve disposed downstream from said diffuser portion and responsive to said flow of gas.

12. (New) The device of claim 10, wherein said diffuser has a conical contour.

13. (New) A method for achieving flow through a flow control valve in a well having a tubing concentrically spaced within a casing by an annulus, comprising the steps of:

placing a gas lift valve within the well at, a predetermined location, said gas lift valve having an inlet end in communication with said annulus, and an outlet end in communication with an interior of said tubing;

flowing compressed gas of density less than a density of reservoir fluids into the annulus;

flowing the compressed gas from the annulus into a convergent nozzle portion of the gas lift valve;

gradually accelerating gas flow through said nozzle portion;

gradually slowing down said gas flow in a divergent outlet portion of the gas lift valve, thereby reducing the gas pressure loss and rendering the gas flow isoentropic; and

mixing gas ejected from the outlet portion of the gas lift valve with reservoir fluids in the tubing.

14. (New) A method as in claim 13, further comprising flowing gas ejected from the outlet portion through a check valve before said mixing step.--